

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	2040	438/22,32,48,55.ccls.	US-PGPUB; USPAT	OR	ON	2005/02/17 14:18
L2	249	1 and (MEMS or microelectronics)	US-PGPUB; USPAT	OR	ON	2005/02/17 14:21
L3	1510	257/414,432,444.ccls.	US-PGPUB; USPAT	OR	ON	2005/02/17 14:19
L4	189	3 and (MEMS or microelectronics)	US-PGPUB; USPAT	OR	ON	2005/02/17 14:20
L5	167	4 not 2	US-PGPUB; USPAT	OR	ON	2005/02/17 14:20
L7	37096	(MEMS or microelectronics) and substrate and (via or trench or recess or opening or hole or aperture)	US-PGPUB; USPAT	OR	ON	2005/02/17 14:29
L8	22196	7 and @ad<"20010824"	US-PGPUB; USPAT	OR	ON	2005/02/17 14:31
L9	733	8 and (conductive with epoxy)	US-PGPUB; USPAT	OR	ON	2005/02/17 14:24
L10	222	9 and (optical or lens or waveguide or prism)	US-PGPUB; USPAT	OR	ON	2005/02/17 14:25
L11	12602	(MEMS or microelectronics) and interconnect	US-PGPUB; USPAT	OR	ON	2005/02/17 14:33
L12	9316	11 and via	US-PGPUB; USPAT	OR	ON	2005/02/17 14:33
L13	7406	12 and substrate	US-PGPUB; USPAT	OR	ON	2005/02/17 14:33
L14	2217	13 and face	US-PGPUB; USPAT	OR	ON	2005/02/17 14:30
L15	1252	14 and @ad<"20010824"	US-PGPUB; USPAT	OR	ON	2005/02/17 14:31
L16	12374	(MEMS or microelectronics) and interconnect	USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2005/02/17 14:33
L17	1455	16 and via	USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2005/02/17 14:33
L18	182	17 and substrate	USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2005/02/17 15:10
L19	933	(silicon adj nitride) and (GaN or(gallium adj nitride)) and epitaxial\$2 and temperature	US-PGPUB; USPAT	OR	ON	2005/02/17 16:46

L20	221	19 and monolayers	US-PGPUB; USPAT	OR	ON	2005/02/17 15:13
L21	166	20 and @ad<"20010921"	US-PGPUB; USPAT	OR	ON	2005/02/17 16:36
L22	161	21 and (thermal or annealing or heating)	US-PGPUB; USPAT	OR	ON	2005/02/17 16:38
L23	1	21 and ((gallium adj nitride) same (thermal or annealing or heating))	US-PGPUB; USPAT	OR	ON	2005/02/17 16:40
L24	7	21 and ((GaN) same (thermal or annealing or heating))	US-PGPUB; USPAT	OR	ON	2005/02/17 16:40
L25	4	(silicon adj nitride) and (GaN or(gallium adj nitride)) and epitaxial\$2 and temperature	USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2005/02/17 17:02
L26	13	((silicon adj nitride) or "Si.sub.3N.sub.4") and (GaN or(gallium adj nitride)) and epitaxial\$2	USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2005/02/17 17:08
L27	1097	((silicon adj nitride) or "Si.sub.3N.sub.4") and (GaN or(gallium adj nitride)) and epitaxial\$2	US-PGPUB; USPAT	OR	ON	2005/02/17 17:09
L28	294	((silicon adj nitride) or "Si.sub.3N.sub.4") same (GaN or(gallium adj nitride))) and epitaxial\$2	US-PGPUB; USPAT	OR	ON	2005/02/17 17:09
L29	177	28 and ((GaN or(gallium adj nitride)) with epitaxial\$2)	US-PGPUB; USPAT	OR	ON	2005/02/17 17:10

US-PAT-NO: 6794276

DOCUMENT-IDENTIFIER: US 6794276 B2

****See image for Certificate of Correction****

TITLE: Methods for fabricating a substrate

----- KWIC -----

Detailed Description Text - DETX (20):

The seed layer preferably comprises materials such as sapphire, silicon carbide, zinc oxide, and [111] silicon. The seed layer may also be selected to obtain a precise crystal structure and orientation, for example to obtain hexagonal or cubic gallium nitride, or if an Si face or a C face is selected to deposit the working layer on a seed layer of silicon carbide; the seed layer is made of gallium nitride of very high quality, i.e. having fewer than 10.sup.6 dislocations per square centimeter, e.g. gallium nitride obtained by the epitaxial lateral overgrowth (ELOG) technique.

Detailed Description Text - DETX (53):

This embodiment may have variants such as the seed layer 2 of [111] silicon can be replaced by monocrystalline silicon carbide, sapphire, neodymium gallate, or lithium gallate; the bonding layers 10 and 11 of silicon oxide can be replaced by silicon nitride; the polycrystalline silicon carbide support 12 can be replaced by monocrystalline silicon carbide or by sapphire; and the thick layer 4 of diamond can be replaced by polycrystalline silicon carbide, by polycrystalline gallium nitride (e.g. deposited by HVPE), by boron nitride, or by a metal such as copper, etc. (e.g. deposited as a thick layer by electrolysis).

Detailed Description Text - DETX (65):

The seed layer 2 of monocrystalline silicon carbide or the working layer 16 of monocrystalline gallium nitride can be subjected to various additional technological steps prior to being subjected to deposition of the thick layer 4, these steps seeking to provide some or all of the electronic components, or comprising making uniform deposits of additional films, either epitaxially or otherwise.

Detailed Description Text - DETX (69):

The support 12 can be made of polycrystalline silicon carbide or of polycrystalline silicon nitride or of polycrystalline aluminum nitride or of sapphire or of polycrystalline gallium nitride, instead of being made of monocrystalline silicon carbide. The thick layer 4 can be made of polycrystalline aluminum nitride, of diamond, or of boron nitride, instead of being made of polycrystalline silicon carbide.

US-PAT-NO: 6852161

DOCUMENT-IDENTIFIER: US 6852161 B2

TITLE: METHOD OF FABRICATING GROUP-III NITRIDE SEMICONDUCTOR CRYSTAL, METHOD OF FABRICATING GALLIUM NITRIDE-BASED COMPOUND SEMICONDUCTOR, GALLIUM NITRIDE-BASED COMPOUND SEMICONDUCTOR, GALLIUM NITRIDE-BASED COMPOUND SEMICONDUCTOR LIGHT-EMITTING DEVICE, AND LIGHT SOURCE USING THE SEMICONDUCTOR LIGHT-EMITTING DEVICE

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Brief Summary Text - BSTX (62):

The above method encompasses the mask layer formation step being performed in a same epitaxial growth apparatus in which the gallium nitride-based compound semiconductor is grown.

Detailed Description Text - DETX (58):

As shown in FIG. 9(a), source gas 3 containing Si and ammonia gas 4 are flowed to react the two compounds and form a silicon nitride film 5 on the sapphire substrate 1 heated to a prescribed temperature. Because the formation of the film 5 starts from active points scattered across the substrate, initially the film 5 does not uniformly cover the whole substrate. The growth time is controlled so that on the substrate 1, there are regions covered by the silicon nitride film 5 and regions 6 where the sapphire is exposed (FIG. 9(b)). Continuing on, after droplet-shaped particles 7 of a group III element are supplied to the regions 6 by flowing group III material gas 3' (FIG. 9(c)), ammonia is flowed to effect a reaction that produces group-III nitrides 8 in the regions 6 (FIG. 9(d)). Thus, growth nuclei in the regions covered by the silicon nitride film 5 do not generate growth, while crystals 9 do grow from the regions 6 where the sapphire is exposed, with the growth proceeding horizontally over the silicon nitride film 5 (FIG. 9(f)). As a result, the crystals 9 cover the entire surface of the sapphire substrate 1 (FIG. 9(g)). The growth direction of threading dislocations arising from differences in the lattice constants of the sapphire and gallium nitride-based compound semiconductor can be controlled, with most of the dislocations forming a closed loop and not propagating upwards. This reduces the density of threading dislocations, resulting in the formation of good-quality crystal.

Detailed Description Text - DETX (61):

In the case of the methods described with reference to FIGS. 9 and 10, processing and growth following formation of the mask layer have to be done at a temperature of at least 1000.degree. C. This is because at a lower temperature such as 600.degree. C., there will be insufficient migration during the formation of the group III metal particles 7 and the gallium nitride-based compound semiconductor film 8. As a result, growth nuclei will

start to grow even in regions of the substrate 1 and buffer layer covered by the silicon oxide and silicon nitride, degrading the selective growth properties. Even when a layer of gallium nitride-based compound semiconductor 9 is formed on this mask layer, at a low temperature such as 600.degree. C. there will be insufficient migration during the initial growth phase, so the growth nuclei will start to grow even in the regions of the substrate 1 and buffer layer covered by the silicon oxide and silicon nitride, degrading the selective growth properties. Silane (SiH_4) and disilane (Si_2H_6) can be used as a Si source gas. The step of forming the mask layer can be performed in the growth apparatus used for the following growth of the gallium nitride-based compound semiconductor.

Detailed Description Text - DETX (66):

After the substrate was positioned in the apparatus, it was heated to 1180.degree. C. in a hydrogen atmosphere and held at that temperature for 10 minutes to remove any oxide film from the substrate surface. The temperature was then reduced to 1100.degree. C., and in the same hydrogen atmosphere not containing a nitrogen source, a metallo-organic material, trimethyl aluminum (TMA), was supplied to the substrate for 1 minute at a flow rate of 12 $\mu\text{mol/min}$. The TMA was thus thermally decomposed, resulting in the deposition of Al on the sapphire substrate. After shutting off the TMA, the temperature was raised to 1180.degree. C. and a nitrogen source, in the form of ammonia (NH_3) was supplied for 3 minutes at a flow rate of 0.2 mol/min, nitriding the Al. Then, with the NH_3 flow rate unchanged and the temperature maintained at 1180.degree. C., a metallo-organic material, trimethyl gallium (TMG), was supplied at a flow rate of 140 $\mu\text{mol/min}$ to effect epitaxial growth of a 1.1 μm layer of gallium nitride on the substrate with the Al deposition. The apparatus was then allowed to cool to room temperature and the substrate was removed from the reactor.

Detailed Description Text - DETX (67):

The epitaxial wafer thus fabricated had a mirror surface, and the peak width at half height of the X-ray rocking curve of the epitaxial layer of gallium nitride was 959 seconds. This shows the excellent crystallinity of the epitaxial layer.

Detailed Description Text - DETX (69):

As in the case of Example 1, a sapphire single-crystal substrate with a (0001) plane was organically cleaned and heat-treated in the growth apparatus. With the substrate then maintained at 1180.degree. C. in a hydrogen atmosphere not containing a nitrogen source, it was supplied with TMA and TMG for 1 minute at a flow rate of 12 $\mu\text{mol/min}$, depositing an alloy of Al and Ga on the sapphire substrate. The TMA and TMG were shut off and, with the temperature maintained at 1180.degree. C., ammonia was supplied for 3 minutes at a flow rate of 0.2 mol/min to nitride the Al--Ga alloy. Then, with the ammonia being supplied and the temperature still maintained at 1180.degree. C., a metallo-organic material, trimethyl gallium (TMG), was supplied at a flow rate of 140 $\mu\text{mol/min}$ to effect epitaxial growth of a 1.1 μm layer of gallium nitride on the substrate with the Al--Ga alloy deposition.

Detailed Description Text - DETX (70):

The epitaxial wafer thus fabricated had a mirror surface, and the peak width at half height of the X-ray rocking curve of the epitaxial layer of gallium nitride was 720 seconds, indicating the excellent crystallinity of the epitaxial layer. Examination of the surface of the gallium nitride layer by an atomic force microscope revealed terraces of atomic steps indicating step-flow growth. These atomic-step terraces showed more uniform spacing and parallelism, going in a particular direction from the center of the epitaxial wafer to the periphery. This signifies that the step-flow growth is reinforced at (0001) plane portions at the wafer periphery where the vertical axis is tilted from $\langle 0001 \rangle$ in a specific direction. This direction was $\langle 1-100 \rangle$.

Detailed Description Text - DETX (74):

An atomic force microscope was used to examine the surface of the wafer thus fabricated. Nitrided polycrystals of metal particles were observed that were around 50 nm high and around 0.1 μm in diameter. The polycrystals did not cover the entire surface of the sapphire substrate: there were flat spaces between polycrystals. It is considered that the epitaxial growth of the gallium nitride layer of Example 2 proceeded with the polycrystals acting as nuclei.

Detailed Description Text - DETX (79):

The epitaxial wafer thus fabricated had a mirror surface, and the peak width at half height of the X-ray rocking curve of the epitaxial layer of gallium nitride was 620 seconds. This indicates the excellent crystallinity of the epitaxial layer. While the above Examples 1 to 3 describe epitaxial growth of group-III nitride semiconductor crystal in the form of a layer of gallium nitride, it is also possible to grow a group-III nitride semiconductor that is a mixed crystal, represented by $\text{In}_{\text{sub.x}}\text{Ga}_{\text{sub.y}}\text{Al}_{\text{sub.z}}\text{N}$.

Detailed Description Text - DETX (82):

FIG. 6 shows the epitaxial structure used for the light-emitting device fabricated in accordance with Example 4. The lattice mismatch epitaxial growth method is used to form, on a c-plane sapphire substrate 11, a 2- μm low Si doped GaN layer 12 having an electron concentration of $1 \times 10^{17} \text{ cm}^{-3}$, followed by a 1- μm highly Si doped GaN layer 13 having an electron concentration of $1 \times 10^{19} \text{ cm}^{-3}$, a 100-Å $\text{In}_{\text{sub.0.1}}\text{Ga}_{\text{sub.0.9}}\text{N}$ cladding layer 14 having an electron concentration of $1 \times 10^{17} \text{ cm}^{-3}$, a multi quantum well structure that starts and ends with GaN barrier layers, and comprises six 70-Å GaN barrier layers 15 and five 20-Å non-doped $\text{In}_{\text{sub.0.2}}\text{Ga}_{\text{sub.0.8}}\text{N}$ well layers 16, a 30-Å $\text{Al}_{\text{sub.0.2}}\text{Ga}_{\text{sub.0.8}}\text{N}$ diffusion prevention layer 17, an 0.15- μm Mg-doped GaN layer 18 having a hole-concentration of $8 \times 10^{17} \text{ cm}^{-3}$, and a 100-Å Mg-doped $\text{In}_{\text{sub.0.1}}\text{Ga}_{\text{sub.0.9}}\text{N}$ layer 9 with a hole-concentration of $5 \times 10^{18} \text{ cm}^{-3}$. FIG. 7 is a plan view of the electrode structure of this light-emitting device embodiment of Example 4.

Detailed Description Text - DETX (207):

An example will now be described in which gallium nitride-based compound semiconductor crystal is grown using a slow-growth mask layer formed on the substrate. In this example, the crystal was grown on the substrate in accordance with the steps shown in FIG. 9. The MOCVD method was used to fabricate an epitaxial specimen by flowing ammonia and disilane (Si.sub.2 H.sub.6), then flowing a mixture of TMG and TMA, then flowing ammonia to form on a substrate heated to a high temperature, a mask layer having a region covered by silicon nitride and a region where aluminum nitride and gallium nitride were adhered to the sapphire substrate, and forming a non-doped GaN layer on that layer.

Detailed Description Text - DETX (211):

After completion of the thermal cleaning, the ammonia and disilane gas valves were used to effect flowing of ammonia and disilane gas over the sapphire substrate for 1 minute, when the valves were used to stop the supply of the ammonia and disilane gas. Next, the nitrogen carrier gas valve was used to start supplying the reactor with nitrogen gas. After 1 minute, the TMA and TMG valves were turned on to supply the reactor with carrier gas containing TMG and TMA vapor for 1 minute, after which the supply of TMA and TMG was shut off and the carrier gas valve was used to start nitrogen flowing to the reactor. After 1 minute, the supply of ammonia to the reactor was started, and continued for 10 minutes, when it was turned off and the nitrogen supply turned on. The mask layer formed by these steps comprised silicon nitride regions 5 and gallium nitride aluminum regions 8.

Detailed Description Text - DETX (216):

In this example, the crystal was grown on the substrate by the steps shown in FIG. 10, using the MOCVD method. The surface of a sapphire substrate was nitrified by flowing ammonia gas at a high temperature. A mask layer was formed on the substrate by flowing a mixture of silane and TMG and then flowing ammonia, to form a mask layer comprising a region covered by silicon nitride and a region where gallium nitride adhered to the substrate. A non-doped GaN layer was then formed on the mask layer.

Detailed Description Text - DETX (217):

The MOCVD method was used to fabricate a specimen that included the above GaN layer, as follows, using the same MOCVD apparatus as Example 13. Thus, a sapphire substrate was thermally cleaned in the same way as in Example 13, during which bubbling was started. After completion of the thermal cleaning, the ammonia was flowed over the substrate for 20 minutes and then stopped. Next, the nitrogen carrier gas valve was operated to start supplying the reactor with nitrogen gas. Then, the silane and TMG valves were turned on to supply the reactor with carrier gas containing silane and TMG vapor for 30 seconds, after which the TMG and silane were shut off and the carrier gas valve was used to start the delivery of nitrogen to the reactor. After 1 minute, a flow of ammonia to the reactor was started and continued for 10 minutes, after which it was turned off and the nitrogen supply turned on. This process formed a mask layer on the sapphire substrate comprising silicon nitride regions 5 and

gallium nitride regions 8.

Detailed Description Text - DETX (221):

This example is used to describe a method of fabricating a light-emitting device using **gallium nitride**-based compound semiconductor that includes a step of fabricating the **gallium nitride**-based compound semiconductor by the method described in Example 13. The cross-sectional structure of the light-emitting device thus fabricated had the same structure as Example 12, shown in FIG. 8. The MOCVD method was used to form a wafer having this multilayer structure for a semiconductor light-emitting device, by flowing ammonia and disilane ($\text{Si}_{0.2}\text{H}_{0.6}$), then a mixture of TMG and TMA, then ammonia to form, on a sapphire substrate heated to a high temperature, a mask layer having a region covered by **silicon nitride** and a region covered with GaAlN. The following layers were then formed thereon, in the following order: a 2- μm low Si doped **GaN** layer 12 having an electron concentration of $1 \times 10^{17} \text{ cm}^{-3}$; a 1- μm highly Si doped **GaN** layer 13 having an electron concentration of $1 \times 10^{19} \text{ cm}^{-3}$; a multi quantum well structure that started with a **GaN** barrier layer 15 and ended with a **GaN** barrier layer 15, comprising six 70- \AA **GaN** barrier layers 15 and five 20- \AA non-doped $\text{In}_{0.2}\text{Ga}_{0.8}\text{N}$ well layers 16; a 30- \AA $\text{Al}_{0.2}\text{Ga}_{0.8}\text{N}$ diffusion prevention layer 17; and an 0.15- μm Mg-doped **GaN** layer 18 having a hole-concentration of $8 \times 10^{17} \text{ cm}^{-3}$.

Claims Text - CLTX (14):

14. The method according to claim 12, wherein the step of forming the mask layer is performed in an epitaxial growth apparatus used to grow the **gallium nitride**-based compound semiconductor crystal.

Claims Text - CLTX (29):

29. The method according to claim 27, wherein the step of forming the mask layer is performed in an epitaxial growth apparatus used to grow the **gallium nitride**-based compound semiconductor crystal.

Claims Text - CLTX (39):

39. The method according to claim 37, wherein the step of forming the mask layer is performed in an epitaxial growth apparatus used to grow the **gallium nitride**-based compound semiconductor crystal.

Claims Text - CLTX (62):

62. The method according to claim 60, wherein the step of forming the mask layer is performed in an epitaxial growth apparatus used to grow the **gallium nitride**-based compound semiconductor crystal.

Claims Text - CLTX (80):

80. The method according to claim 78, wherein the step of forming the mask layer is performed in an epitaxial growth apparatus used to grow the **gallium nitride**-based compound semiconductor crystal.